

Analysis of Parking Performance of Public Off-Street Parks in Baghdad City

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ABSTRACT

Parking is an important part of the transport system and its problems, especially in the capitals of countries, are due to dense traffic, business districts, private vehicle use, and the number of population as compared to the area of cities. The purposes of the study are assessing of the efficiency of parking operation including Parking Index (PI), Parking Duration (PD) and Parking Turnovers (PT). The study area included four parks was to be selected in Baghdad city in Iraq based on the advantages of the land use, two in Al-Karkh area and the others in Al-Rusafa area. Parking data were surveyed manually to evaluate parking performance of each park depending on initial questionnaires and previous data. Arrival-Departure method is used for evaluating PI, PD, and PT which express the case of parking efficiency. It showed that PI is 57.00, 97.72, 39.39 and 35.71%, also PD is 41.71, 43.11, 42.67 and 38.88 min, in addition that PT is 0.82, 1.36, 0.55, 0.55 veh/space for P1, P2, P3 and P4 respectively. The study showed that P1 and P2 operated below the maximum capacity at PI lower than 50%, it also gave the indication that P2 sometimes operates with an overcapacity, this may due to bad management of the park in addition to the non-properly use for the electronic system which controls on entrance gates. Furthermore, it showed that P3 and P4 operated above the maximum capacity complying with policy 7 of the parking space requirements in parking code guidance 2012 of San Francisco Department of Transportation.

Key Words: Arrival-Departure Method, Parking Index, Parking Duration, Parking Turnovers.

1. INTRODUCTION

Parking facilities is an essential element of the highway mode of transportation. Any vehicle traveling on highways will at one time or another be parked at some point for either a relatively short time or a much longer time, based on the reason for parking. The growing use of the automobile systems as a personal feeder service has been increased the parking spaces demand at transit stations. In a high density areas, especially in capitals, providing adequate parking bays to meet the parking demand is very necessary to reduce the capacity of the streets and absolutely affect the level of service (LOS).

Parking is one of the major problems created by increasing road traffic; it has an effectiveness on the improvement of transportation. Less space availability in urban areas results in increasing the parking space demand, especially in CBD affects the choice of mode and has a great economic impact. With the increasing growth in vehicle population on road, the problem of parking has assumed serious proportions in the study area. As a result, a systematic study of parking characteristic, demand, and regulatory measures that are possible for the control of vehicle is very important. The purpose of this study is to analyze the performance of off-street parks in Baghdad with a view to identify the various factors influencing the supply of parking facilities.

2. LITTERATURE REVIEW AND THEORETICAL BACKGROUND

According to reference [1], parking surveys are conducted to collect the parking statistics. Since the duration of parking varies with different vehicles, several statistics are used to access the parking need. The most important parking statistics are Parking accumulation (PA) which is defined as the number of vehicles parked at a given instant of time. It can be plotted as a curve of parking accumulative against time. While Parking Volume (PV) is the total number of vehicles parked at a given duration of time or it means the sum of Initial account (I) of parked vehicle before survey and the number of Arrivals (A) during survey interval as shown in (1). It does not account for repetition of vehicles. It means the actual number of vehicles entered in the area. On the other hand, Parking Load (PL) gives the area under the accumulation curve. It can be obtained by simply multiplying the number of vehicles occupying the parking area at each time interval with the time interval. Finally, three important parameters which give indications of parking supply is Parking Index (PI) which is also called Parking Occupancy and it is defined as the ratio of parking load to the Number of spaces available (N) as in (2). Also, Average Parking Duration (PD) which it is the ratio of parking load to the parking volume as in (3). Furthermore, Parking Turnover (PT) which is the ratio of parking volume to the number of parking spaces available. This can be expressed as number of vehicles per bay per time duration as in (4).

$$PV = I + A \quad \text{-----} \quad (1)$$

$$PI = PL / N \quad \text{-----} \quad (2)$$

$$PD = PL / PV \quad \text{-----} \quad (3)$$

$$PT = PV / N \quad \text{-----} \quad (4)$$

Reference [2] on traffic congestion and parking difficulties in Akure metropolis, Nigeria, they showed that parking problem in the CBD of Akure is a major reason of traffic congestion. Constitutes of on-street parking is one major problem that makes the traffic situation chaotic in Nigerian cities. Because most of the roads in Nigerian cities are narrow and lack pedestrian lanes; parking along these narrow roads therefore results in traffic congestion. This is due to the unavailability of off-street parking facilities along the routes of transportation coincides with inadequate management of traffic [3]. According to the reference [4] license plate method was used to analyze the collected data related to campus population and car ownership. The data were analyzed to determine major parking characteristics in study area and define current parking inadequacies and the anticipated future parking situation in the study area. According to the projection formulas were developed, the additional parking supply needed by the target year 2015 were 644 spaces in order to cover the demand of future parking in the study area. On the other hand, in western countries, standards requirements for parking have been rechecked towards limiting the use of private car in congested central areas but obtaining minimum levels to conserve activities of city center. This is most feasible in urbanized areas, where activities are interacted because of land use mixes and bad public transportation system that would decrease uses of private cars [5]. Cities are classified in its characteristics by different land uses activities. The efficiency of this characterization based on existing transportation systems, of which parking facilities to be expressed as a major component [6]. According to reference [7], in situations of provision lack and weak planning as related the activities of other urban land use, the increasing in numbers of vehicles without any adequate infrastructure will increase the problems of traffic congestion, traffic delays, parking problems, accidents, and urban land use severance. Vehicles are one of the dominant modes of transportation, urban circulation is one of the most commonly problems and parking seems to be an important element in development of transportation [8]. Development in the standards of people living caused to increase in fares as much as the growth of cities to contemporary urban traffic. However, for a city to limit as a system, transportation must be efficient and reliable to facilitate, not only intercity movement of people and their activities, but encourage intra-city movements within the city. These movements are from point of origin to the destination [9].

4. STUDY AREA

The study area lies in the capital Baghdad in "Al-Karkh" and "Al-Rusafa" areas. It represents four important parks are Al-Ummah Park (P1), 9 Nissan Park (2), Al-Bayaa Park (P3), Allawi Southern Park (4). The reason to choses these parks based on the advantages of the land use, and provision of the initial questionnaires and data collected from the State Company for Private Transport which subordinate to the Ministry of Transportation in Baghdad City. A brief description for each park is expressed in Table 1.1. The location of parks around the area is shown in Figure 1.1, while the geometric details of study area for each one is shown from Figure 1.2 to 1.5 using Google Maps from the Central of Geographic Information System.

Table 1.1 Details of Parks

| Sr. | Park Name | Park Code | Capacity (No. of Spaces) | Approximated Cross Sectional Area (m ²) | District/ Area | Park Use Characteristics | Global Coordination | |
|-----|--------------------|-----------|-----------------------------|---|----------------------------|-------------------------------|---------------------|------------|
| | | | | | | | Longitude | Latitude |
| 1 | Al-Ummah | P1 | 100 | 6800 | Bab Al-Sharqi/ Rusafa | Residential | -44.408880 | -33.329158 |
| 2 | 9 Nissan | P2 | 150 | 5600 | New- Baghdad/ Rusafa | Residential | -44.470744 | -33.310318 |
| 3 | Al-Bayaa | P3 | 260 | 7800 | Al-Bayaa/ Al-Karkh | Residential | -44.338100 | -33.261009 |
| 4 | Allawi Southern | P4 | 1000 | 21275 | Al-Allawi/ Al-Karkh | Residential and Commercial | -44.408880 | -33.329158 |

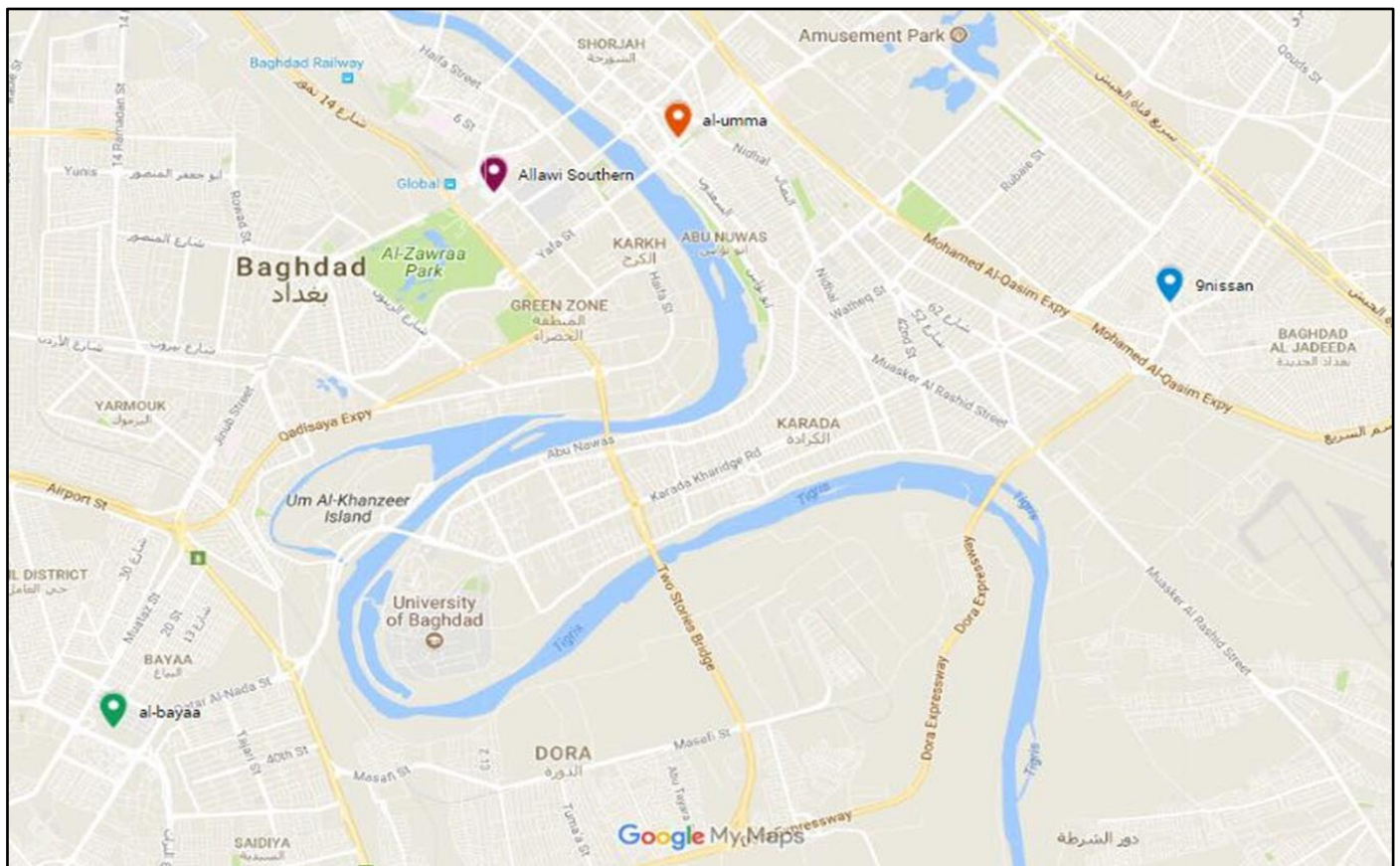


Figure 1.1 Google Maps of Parks Location

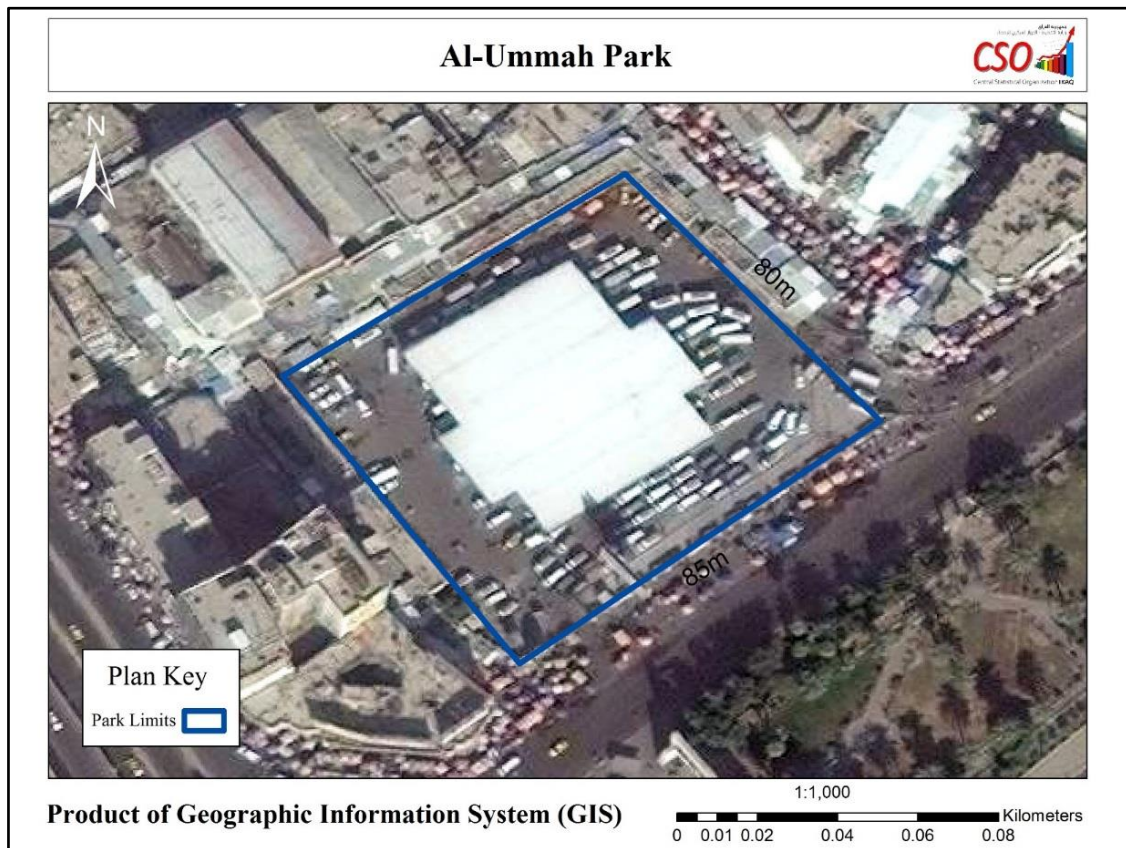


Figure 1.2 Google Maps of Al-Ummah Park Location



Figure 1.3 Google Maps of 9 Nissan Park Location



Figure 1.4 Google Maps of Al-Bayaa Park Location

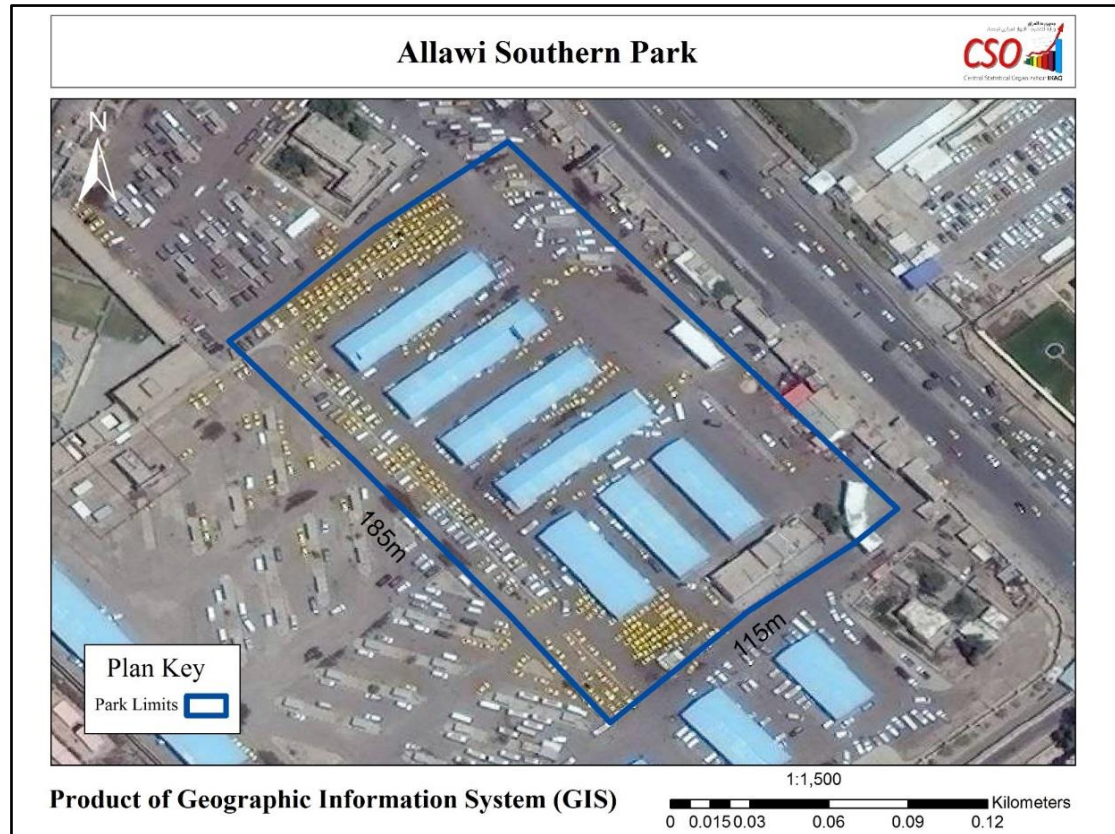


Figure 1.5 Google Maps of Allawi Southern Park Location

5. ASSESSMENT OF METHODOLOGY

The most common parking surveys conducted on parking studies are Arrival-Departure and license plate methods of survey. In this study, Arrival-Departure Method is used for surveying. The occupancy count in the selected parking area is taken at the beginning, also the number of vehicles that enter (Arrival) and leave (Departure) the parking area for a particular time interval is counted. Furthermore, the final PI, PD and PT in the parking area is obtained to show the operation performance of each park. The advantage of this survey that the labor required is very less, two persons may be enough, while the disadvantage that it cannot estimate the parking fare (income) fairly from this survey. The total mentioned procedure of the study is shown in Figure 1.6.

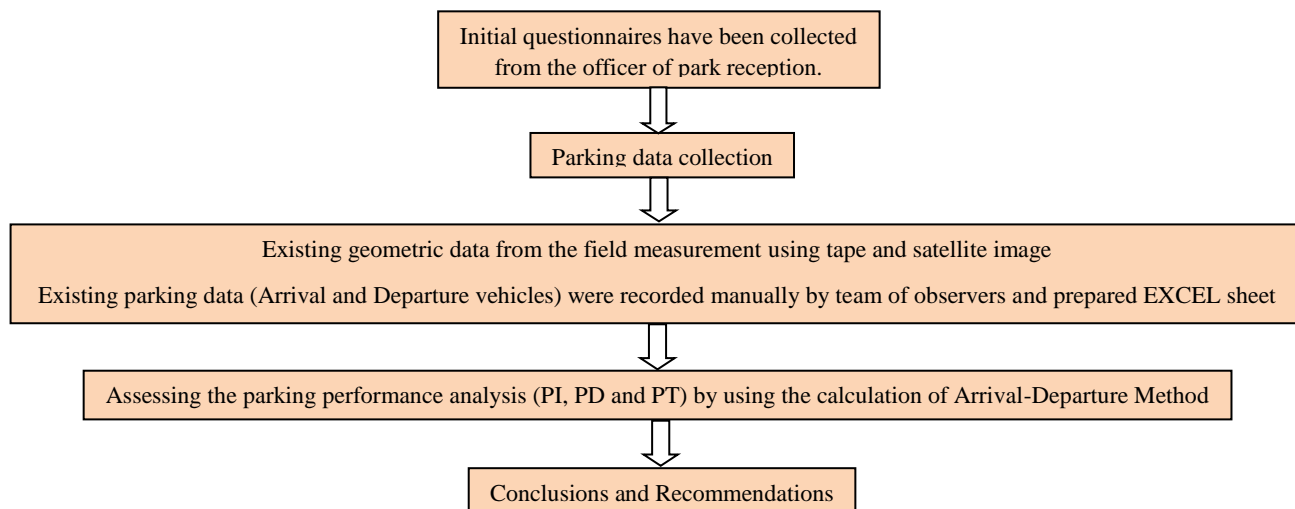


Figure 1.6 Procedure of the Study Methodology

5. DATA COLLECTION

Required geometric and parking data are collected manually by a group of engineers based on the initial questionnaires and collected previous data during different days (three hours per day was taken in consideration to obtain peak hour) as shown later.

5.1 Al-Ummah Park (P1)

Data was collected on April 10, 2018 as shown in Table 1.2. The Initial count of vehicles before beginning of survey was 57, where the number of park spaces is 100. The number of arrival and departure vehicles were obtained. Based on the questionnaires, the peak hour of parked vehicles is during the interval from (1:00-4:00) P.M.

Table 1.2 Arrival-Departure vehicles of Al-Ummah Park

| Time (min) P.M. | Arrival | Departure | Time (min) P.M. | Arrival | Departure | Time (min) P.M. | Arrival | Departure |
|--------------------|---------|-----------|--------------------|---------|-----------|--------------------|---------|-----------|
| 1:00-1:05 | 1 | 2 | 2:00-2:05 | 2 | 4 | 3:00-3:05 | 2 | 2 |
| 1:05-1:10 | 1 | 1 | 2:05-2:10 | 3 | 7 | 3:05-3:10 | 0 | 2 |
| 1:10-1:15 | 3 | 2 | 2:10-2:15 | 3 | 6 | 3:10-3:15 | 3 | 4 |
| 1:15-1:20 | 2 | 3 | 2:15-2:20 | 1 | 8 | 3:15-3:20 | 1 | 2 |
| 1:20-1:25 | 1 | 1 | 2:20-2:25 | 4 | 4 | 3:20-3:25 | 0 | 1 |
| 1:25-1:30 | 5 | 4 | 2:25-2:30 | 6 | 7 | 3:25-3:30 | 4 | 5 |
| 1:30-1:35 | 4 | 2 | 2:30-2:35 | 5 | 5 | 3:30-3:35 | 3 | 3 |
| 1:35-1:40 | 2 | 2 | 2:35-2:40 | 2 | 3 | 3:35-3:40 | 1 | 5 |
| 1:40-1:45 | 2 | 1 | 2:40-2:45 | 1 | 5 | 3:40-3:45 | 4 | 4 |
| 1:45-1:50 | 1 | 3 | 2:45-2:50 | 1 | 4 | 3:45-3:50 | 1 | 4 |
| 1:50-1:55 | 0 | 2 | 2:50-2:55 | 2 | 3 | 3:50-3:55 | 1 | 3 |
| 1:55-2:00 | 3 | 5 | 2:55-3:00 | 5 | 4 | 3:55-4:00 | 2 | 5 |

5.2 9 Nissan Park (P2)

Data was collected on April 23, 2018 as shown in **Table 1.3**. The Initial count of vehicles before beginning of survey was 73, where the number of park spaces is 150. The number of arrival and departure vehicles were obtained. Based on the questionnaires, the peak hour of parked vehicles is during the interval from (6:00-9:00) A.M.

Table 1.3 Arrival-Departure vehicles of 9 Nissan Park

| Time (min) A.M. | Arrival | Departure | Time (min) A.M. | Arrival | Departure | Time (min) A.M. | Arrival | Departure |
|--------------------|---------|-----------|--------------------|---------|-----------|--------------------|---------|-----------|
| 6:00-6:05 | 14 | 5 | 7:00-7:05 | 15 | 6 | 8:00-8:05 | 13 | 11 |
| 6:05-6:10 | 11 | 3 | 7:05-7:10 | 7 | 5 | 8:05-8:10 | 6 | 8 |
| 6:10-6:15 | 9 | 2 | 7:10-7:15 | 9 | 10 | 8:10-8:15 | 8 | 9 |
| 6:15-6:20 | 5 | 3 | 7:15-7:20 | 7 | 11 | 8:15-8:20 | 5 | 12 |
| 6:20-6:25 | 4 | 1 | 7:20-7:25 | 8 | 16 | 8:20-8:25 | 7 | 7 |
| 6:25-6:30 | 7 | 5 | 7:25-7:30 | 14 | 11 | 8:25-8:30 | 11 | 11 |
| 6:30-6:35 | 13 | 2 | 7:30-7:35 | 15 | 8 | 8:30-8:35 | 9 | 13 |
| 6:35-6:40 | 8 | 6 | 7:35-7:40 | 3 | 13 | 8:35-8:40 | 4 | 6 |
| 6:40-6:45 | 6 | 3 | 7:40-7:45 | 18 | 14 | 8:40-8:45 | 15 | 12 |
| 6:45-6:50 | 11 | 1 | 7:45-7:50 | 11 | 11 | 8:45-8:50 | 10 | 8 |
| 6:50-6:55 | 15 | 4 | 7:50-7:55 | 4 | 11 | 8:50-8:55 | 3 | 5 |
| 6:55-7:00 | 9 | 7 | 7:55-8:00 | 11 | 9 | 8:55-9:00 | 9 | 7 |

5.3 Al-Bayaa Park (P3)

Data was collected on April 19, 2018 as shown in **Table 1.4**. The Initial count of vehicles before beginning of survey was 96, where the number of park spaces is 260. The number of arrival and departure vehicles were obtained. Based on the questionnaires, the peak hour of parked vehicles is during the interval from (1:00-4:00) A.M.

Table 1.4 Arrival-Departure vehicles of Al-Bayaa Park

| Time (min) P.M. | Arrival | Departure | Time (min) P.M. | Arrival | Departure | Time (min) P.M. | Arrival | Departure |
|--------------------|---------|-----------|--------------------|---------|-----------|--------------------|---------|-----------|
| 1:00-1:05 | 2 | 3 | 2:00-2:05 | 1 | 3 | 3:00-3:05 | 1 | 3 |
| 1:05-1:10 | 0 | 2 | 2:05-2:10 | 3 | 0 | 3:05-3:10 | 3 | 2 |
| 1:10-1:15 | 1 | 3 | 2:10-2:15 | 8 | 4 | 3:10-3:15 | 2 | 5 |
| 1:15-1:20 | 3 | 1 | 2:15-2:20 | 6 | 2 | 3:15-3:20 | 0 | 2 |
| 1:20-1:25 | 1 | 2 | 2:20-2:25 | 6 | 7 | 3:20-3:25 | 1 | 6 |
| 1:25-1:30 | 5 | 4 | 2:25-2:30 | 7 | 11 | 3:25-3:30 | 4 | 9 |
| 1:30-1:35 | 1 | 3 | 2:30-2:35 | 5 | 8 | 3:30-3:35 | 3 | 8 |
| 1:35-1:40 | 2 | 0 | 2:35-2:40 | 5 | 3 | 3:35-3:40 | 2 | 5 |
| 1:40-1:45 | 2 | 2 | 2:40-2:45 | 3 | 2 | 3:40-3:45 | 1 | 2 |
| 1:45-1:50 | 4 | 1 | 2:45-2:50 | 1 | 0 | 3:45-3:50 | 2 | 2 |
| 1:50-1:55 | 3 | 1 | 2:50-2:55 | 2 | 4 | 3:50-3:55 | 2 | 4 |
| 1:55-2:00 | 6 | 5 | 2:55-3:00 | 1 | 4 | 3:55-4:00 | 0 | 5 |

5.4 Allawi Southern Park (P4)

Data was collected on April 15, 2018 as shown in **Table 1.5**. The Initial count of vehicles before beginning of survey was 412, where the number of park spaces is 1000. The number of arrival and departure vehicles were obtained. Based on the questionnaires, the peak hour of parked vehicles is during the interval from (1:00-4:00) A.M.

Table 1.5 Arrival-Departure vehicles of Allawi Southern Park

| Time (min) P.M. | Arrival | Departure | Time (min) P.M. | Arrival | Departure | Time (min) P.M. | Arrival | Departure |
|--------------------|---------|-----------|--------------------|---------|-----------|--------------------|---------|-----------|
| 1:00-1:05 | 11 | 10 | 2:00-2:05 | 10 | 15 | 3:00-3:05 | 3 | 14 |
| 1:05-1:10 | 10 | 12 | 2:05-2:10 | 15 | 16 | 3:05-3:10 | 7 | 10 |
| 1:10-1:15 | 8 | 10 | 2:10-2:15 | 9 | 19 | 3:10-3:15 | 9 | 8 |
| 1:15-1:20 | 9 | 9 | 2:15-2:20 | 8 | 18 | 3:15-3:20 | 10 | 6 |
| 1:20-1:25 | 7 | 6 | 2:20-2:25 | 9 | 20 | 3:20-3:25 | 8 | 9 |
| 1:25-1:30 | 9 | 9 | 2:25-2:30 | 11 | 17 | 3:25-3:30 | 5 | 5 |
| 1:30-1:35 | 7 | 6 | 2:30-2:35 | 13 | 15 | 3:30-3:35 | 6 | 8 |
| 1:35-1:40 | 6 | 8 | 2:35-2:40 | 6 | 14 | 3:35-3:40 | 3 | 10 |
| 1:40-1:45 | 5 | 10 | 2:40-2:45 | 12 | 9 | 3:40-3:45 | 6 | 10 |
| 1:45-1:50 | 6 | 11 | 2:45-2:50 | 10 | 10 | 3:45-3:50 | 5 | 7 |
| 1:50-1:55 | 5 | 7 | 2:50-2:55 | 11 | 11 | 3:50-3:55 | 4 | 6 |
| 1:55-2:00 | 4 | 5 | 2:55-3:00 | 10 | 12 | 3:55-4:00 | 4 | 3 |

6. DISCUSSION OF RESULTS

Arrival-Departure Method was used for obtaining the parking performance for each park including PI, PD and PT as stated in details later.

6.1 Al-Ummah Park (P1)

Data results from Table 1.6 and Figure 1.7, shown that the peak hour time for the study of this park is from (1:00-2:00) P.M. It gives average PI, PD and PT of 57.00 %, 41.71 min/veh and 0.82 veh/space respectively, where the PI above the maximum capacity (PI = 50%), therefore; the results classify the park is not adequate in performance.

Table 1.6 Data Results of Al-Ummah Park

| Remarks | | Time (min) P.M. | Arrival | Departure | Accumulation (veh) | Parking Index, PI (%) | Parking load, PL (veh. min.) |
|------------------------|-------|--------------------|---------|-----------|-----------------------|--------------------------|---------------------------------|
| Initial count (veh) | 57 | 1:00-1:05 | 1 | 2 | 56 | 56.00 | 280 |
| Spaces | 100 | 1:05-1:10 | 1 | 1 | 56 | 56.00 | 280 |
| PV (veh) | 82 | 1:10-1:15 | 3 | 2 | 57 | 57.00 | 285 |
| PL (veh. min.) | 3420 | 1:15-1:20 | 2 | 3 | 56 | 56.00 | 280 |
| PD (min) | 41.71 | 1:20-1:25 | 1 | 1 | 56 | 56.00 | 280 |
| PT (veh/space) | 0.82 | 1:25-1:30 | 5 | 4 | 57 | 57.00 | 285 |
| PI (%) | 57 | 1:30-1:35 | 4 | 2 | 59 | 59.00 | 295 |
| Peak Hour | | 1:35-1:40 | 2 | 2 | 59 | 59.00 | 295 |
| | | 1:40-1:45 | 2 | 1 | 60 | 60.00 | 300 |
| | | 1:45-1:50 | 1 | 3 | 58 | 58.00 | 290 |
| | | 1:50-1:55 | 0 | 2 | 56 | 56.00 | 280 |
| | | 1:55-2:00 | 3 | 5 | 54 | 54.00 | 270 |
| | | 2:00-2:05 | 2 | 4 | 52 | 52.00 | 260 |
| | | 2:05-2:10 | 3 | 7 | 48 | 48.00 | 240 |
| | | 2:10-2:15 | 3 | 6 | 45 | 45.00 | 225 |
| | | 2:15-2:20 | 1 | 8 | 38 | 38.00 | 190 |
| | | 2:20-2:25 | 4 | 4 | 38 | 38.00 | 190 |
| | | 2:25-2:30 | 6 | 7 | 37 | 37.00 | 185 |
| | | 2:30-2:35 | 5 | 5 | 37 | 37.00 | 185 |
| | | 2:35-2:40 | 2 | 3 | 36 | 36.00 | 180 |

| | | | | | | |
|--|--------------------------|---|---|----|---------|----------------|
| | 2:40-2:45 | 1 | 5 | 32 | 32.00 | 160 |
| | 2:45-2:50 | 1 | 4 | 29 | 29.00 | 145 |
| | 2:50-2:55 | 2 | 3 | 28 | 28.00 | 140 |
| | 2:55-3:00 | 5 | 4 | 29 | 29.00 | 145 |
| | 3:00-3:05 | 2 | 2 | 29 | 29.00 | 145 |
| | 3:05-3:10 | 0 | 2 | 27 | 27.00 | 135 |
| | 3:10-3:15 | 3 | 4 | 26 | 26.00 | 130 |
| | 3:15-3:20 | 1 | 2 | 25 | 25.00 | 125 |
| | 3:20-3:25 | 0 | 1 | 24 | 24.00 | 120 |
| | 3:25-3:30 | 4 | 5 | 23 | 23.00 | 115 |
| | 3:30-3:35 | 3 | 3 | 23 | 23.00 | 115 |
| | 3:35-3:40 | 1 | 5 | 19 | 19.00 | 95 |
| | 3:40-3:45 | 4 | 4 | 19 | 19.00 | 95 |
| | 3:45-3:50 | 1 | 4 | 16 | 16.00 | 80 |
| | 3:50-3:55 | 1 | 3 | 14 | 14.00 | 70 |
| | 3:55-4:00 | 2 | 5 | 11 | 11.00 | 55 |
| | Total during Peak Hour | | | | 684 % | 3420 veh. min. |
| | Average during Peak Hour | | | | 57.00 % | 57 veh. hr. |

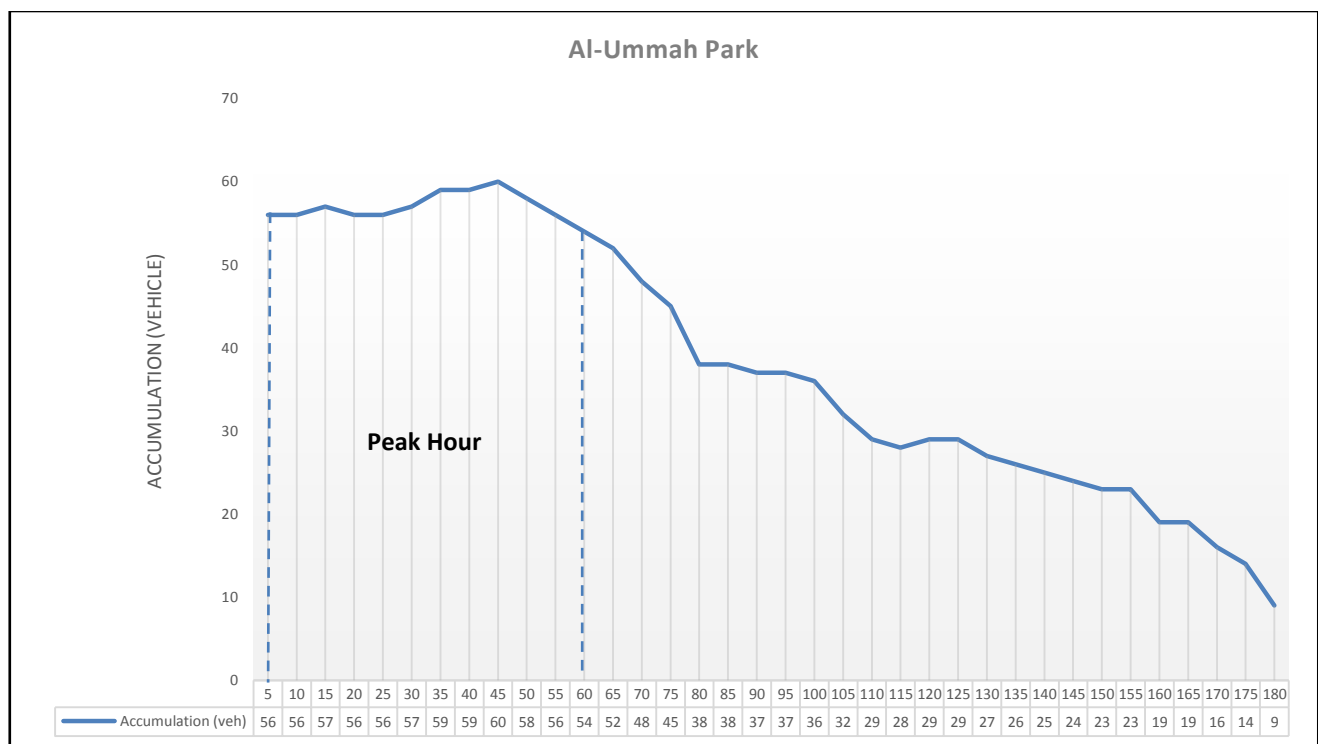


Figure 1.7 Accumulation Curve of Al-Ummah Park

6.2 9 Nissan Park (P2)

Data results from **Table 1.7** and **Figure 1.8**, shown that the peak hour time for the study of this park is from (6:50-7:50) P.M, noted that the park operates on over capacity at the time periods of (7:00-7:15) and (7:30-7:35), which is indicate that there is a clear problem in management of the park system. It also, gives average PI, PD and PT of 97.72 %, 43.11 min/veh and 1.36 veh/space respectively, where PI above maximum capacity (PI = 50%), therefore; results classify the park is not adequate in performance.

Table 1.7 Data Results of 9 Nissan Park

| Remarks | | | Time (min) A.M. | Arrival | Departure | Accumulation (veh) | Parking Index, PI (%) | Parking load, PL (veh. min.) |
|--------------------------|-----------|-----------|--------------------|---------|-----------|-----------------------|--------------------------|---------------------------------|
| Initial count (veh) | 73 | | 6:00-6:05 | 14 | 5 | 82 | 54.67 | 410 |
| | | | 6:05-6:10 | 11 | 3 | 90 | 60.00 | 450 |
| Spaces | 150 | | 6:10-6:15 | 9 | 2 | 97 | 64.67 | 485 |
| PV (veh) | 204 | | 6:15-6:20 | 5 | 3 | 99 | 66.00 | 495 |
| PL (veh. min.) | 8795 | | 6:20-6:25 | 4 | 1 | 102 | 68.00 | 510 |
| PD (min) | 43.11 | | 6:25-6:30 | 7 | 5 | 104 | 69.33 | 520 |
| PT (veh/space) | 1.36 | | 6:30-6:35 | 13 | 2 | 115 | 76.67 | 575 |
| PI (%) | 97.72 | | 6:35-6:40 | 8 | 6 | 117 | 78.00 | 585 |
| | | Peak Hour | 6:40-6:45 | 6 | 3 | 120 | 80.00 | 600 |
| | | | 6:45-6:50 | 11 | 1 | 130 | 86.67 | 650 |
| | | | 6:50-6:55 | 15 | 4 | 141 | 94.00 | 705 |
| 6:55-7:00 | 9 | | 7 | 143 | 95.33 | 715 | | |
| Over Capacity | 7:00-7:05 | | 15 | 6 | 152 | 101.33 | 760 | |
| | 7:05-7:10 | | 7 | 5 | 154 | 102.67 | 770 | |
| | 7:10-7:15 | | 9 | 10 | 153 | 102.00 | 765 | |
| | 7:15-7:20 | | 7 | 11 | 149 | 99.33 | 745 | |
| | 7:20-7:25 | | 8 | 16 | 141 | 94.00 | 705 | |
| | 7:25-7:30 | | 14 | 11 | 144 | 96.00 | 720 | |
| Over Capacity | 7:30-7:35 | | 15 | 8 | 151 | 100.67 | 755 | |
| | 7:35-7:40 | | 3 | 13 | 141 | 94.00 | 705 | |
| | 7:40-7:45 | | 18 | 14 | 145 | 96.67 | 725 | |
| | 7:45-7:50 | | 11 | 11 | 145 | 96.67 | 725 | |
| | 7:50-7:55 | | 4 | 11 | 138 | 92.00 | 690 | |
| | 7:55-8:00 | | 11 | 9 | 140 | 93.33 | 700 | |
| | 8:00-8:05 | 13 | 11 | 142 | 94.67 | 710 | | |
| | 8:05-8:10 | 6 | 8 | 140 | 93.33 | 700 | | |
| | 8:10-8:15 | 8 | 9 | 139 | 92.67 | 695 | | |
| | 8:15-8:20 | 5 | 12 | 132 | 88.00 | 660 | | |
| | 8:20-8:25 | 7 | 7 | 132 | 88.00 | 660 | | |
| | 8:25-8:30 | 11 | 11 | 132 | 88.00 | 660 | | |
| | 8:30-8:35 | 9 | 13 | 128 | 85.33 | 640 | | |
| 8:35-8:40 | 4 | 6 | 126 | 84.00 | 630 | | | |
| 8:40-8:45 | 15 | 12 | 129 | 86.00 | 645 | | | |
| 8:45-8:50 | 10 | 8 | 131 | 87.33 | 655 | | | |
| 8:50-8:55 | 3 | 5 | 129 | 86.00 | 645 | | | |
| 8:55-9:00 | 9 | 7 | 131 | 87.33 | 655 | | | |
| Total during Peak Hour | | | | | | | 1172.67 % | 8795 veh. min. |
| Average during Peak Hour | | | | | | | 97.72 % | 146.58 veh. hr. |

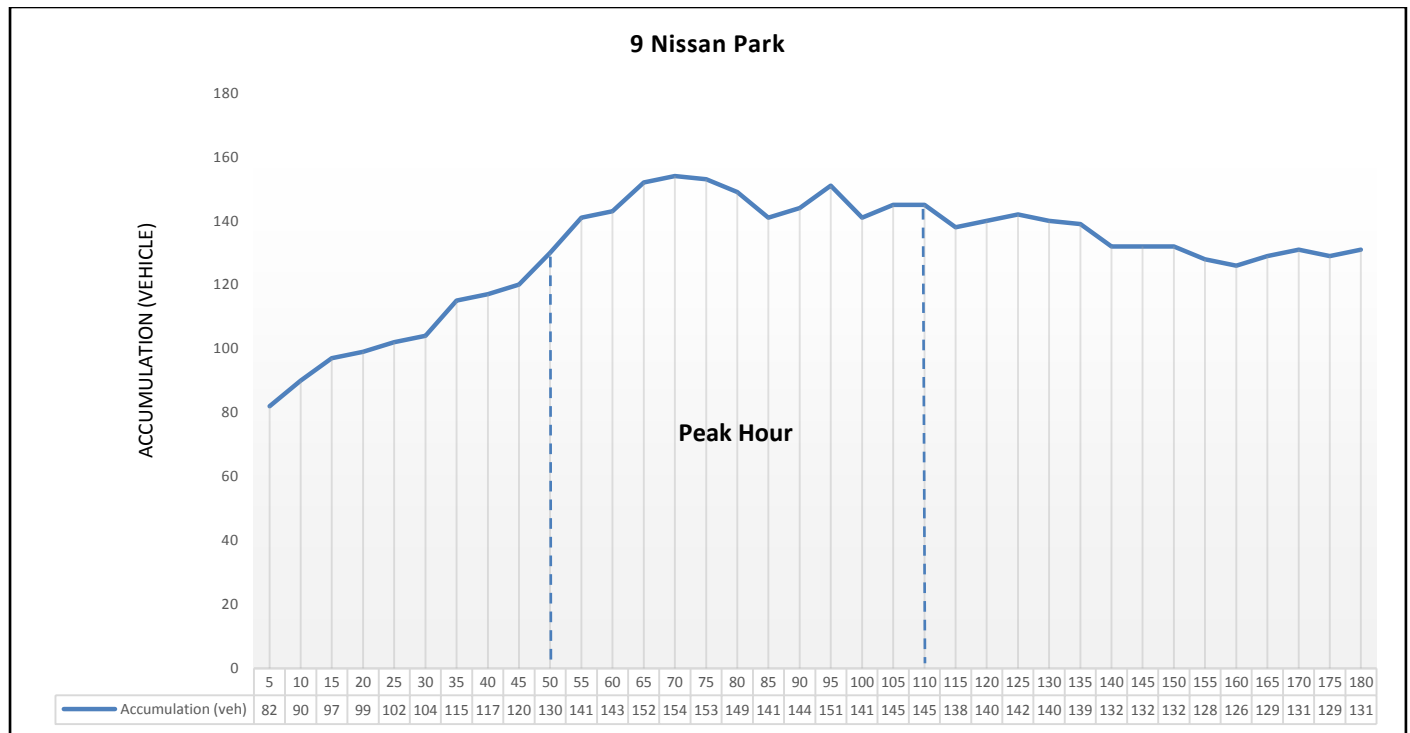


Figure 1.8 Accumulation Curve of 9 Nissan Park

6.3 Al-Bayaa Park (P3)

Data results from Table 1.8 and Figure 1.9, shown that the peak hour time for the study of this park is from (1:00-2:00) P.M. It also, gives average PI, PD and PT of 39.39 %, 42.67 min/veh and 0.55 veh/space respectively, where the PI below the maximum capacity (PI = 50%), therefore; the results classify the park is adequate in performance.

Table 1.8 Data Results of Al-Bayaa Park

| Remarks | | Time (min) P.M. | Arrival | Departure | Accumulation (veh) | Parking Index, PI (%) | Parking load, PL (veh. min.) |
|----------------|-------|--------------------|---------|-----------|-----------------------|--------------------------|---------------------------------|
| Initial count | 96 | 1:00-1:05 | 2 | 3 | 95 | 36.54 | 475 |
| | | 1:05-1:10 | 0 | 2 | 93 | 35.77 | 465 |
| Spaces | 260 | 1:10-1:15 | 1 | 3 | 91 | 35.00 | 455 |
| PV (veh) | 144 | 1:15-1:20 | 3 | 1 | 93 | 35.77 | 465 |
| PL (veh. min.) | 6145 | 1:20-1:25 | 1 | 2 | 92 | 35.38 | 460 |
| PD (min) | 42.67 | 1:25-1:30 | 5 | 4 | 93 | 35.77 | 465 |
| PT (veh/space) | 0.55 | 1:30-1:35 | 1 | 3 | 91 | 35.00 | 455 |
| PI (%) | 39.39 | 1:35-1:40 | 2 | 0 | 93 | 35.77 | 465 |
| | | 1:40-1:45 | 2 | 2 | 93 | 35.77 | 465 |
| | | 1:45-1:50 | 4 | 1 | 96 | 36.92 | 480 |
| | | 1:50-1:55 | 3 | 1 | 98 | 37.69 | 490 |
| | | 1:55-2:00 | 6 | 5 | 99 | 38.08 | 495 |
| | | 2:00-2:05 | 1 | 3 | 97 | 37.31 | 485 |
| | | 2:05-2:10 | 3 | 0 | 100 | 38.46 | 500 |
| | | 2:10-2:15 | 8 | 4 | 104 | 40.00 | 520 |
| | | 2:15-2:20 | 6 | 2 | 108 | 41.54 | 540 |
| | | 2:20-2:25 | 6 | 7 | 107 | 41.15 | 535 |
| | | | | | | | |

| | | | | | | | |
|--|--|--------------------------|---|----|-----|---------|-----------------|
| | | 2:25-2:30 | 7 | 11 | 103 | 39.62 | 515 |
| | | 2:30-2:35 | 5 | 8 | 100 | 38.46 | 500 |
| | | 2:35-2:40 | 5 | 3 | 102 | 39.23 | 510 |
| | | 2:40-2:45 | 3 | 2 | 103 | 39.62 | 515 |
| | | 2:45-2:50 | 1 | 0 | 104 | 40.00 | 520 |
| | | 2:50-2:55 | 2 | 4 | 102 | 39.23 | 510 |
| | | 2:55-3:00 | 1 | 4 | 99 | 38.08 | 495 |
| | | 3:00-3:05 | 1 | 3 | 97 | 37.31 | 485 |
| | | 3:05-3:10 | 3 | 2 | 98 | 37.69 | 490 |
| | | 3:10-3:15 | 2 | 5 | 95 | 36.54 | 475 |
| | | 3:15-3:20 | 0 | 2 | 93 | 35.77 | 465 |
| | | 3:20-3:25 | 1 | 6 | 88 | 33.85 | 440 |
| | | 3:25-3:30 | 4 | 9 | 83 | 31.92 | 415 |
| | | 3:30-3:35 | 3 | 8 | 78 | 30.00 | 390 |
| | | 3:35-3:40 | 2 | 5 | 75 | 28.85 | 375 |
| | | 3:40-3:45 | 1 | 2 | 74 | 28.46 | 370 |
| | | 3:45-3:50 | 2 | 2 | 74 | 28.46 | 370 |
| | | 3:50-3:55 | 2 | 4 | 72 | 27.69 | 360 |
| | | 3:55-4:00 | 0 | 5 | 67 | 25.77 | 335 |
| | | Total during Peak Hour | | | | 472.7 % | 6145 veh. min. |
| | | Average during Peak Hour | | | | 39.39 % | 102.42 veh. hr. |

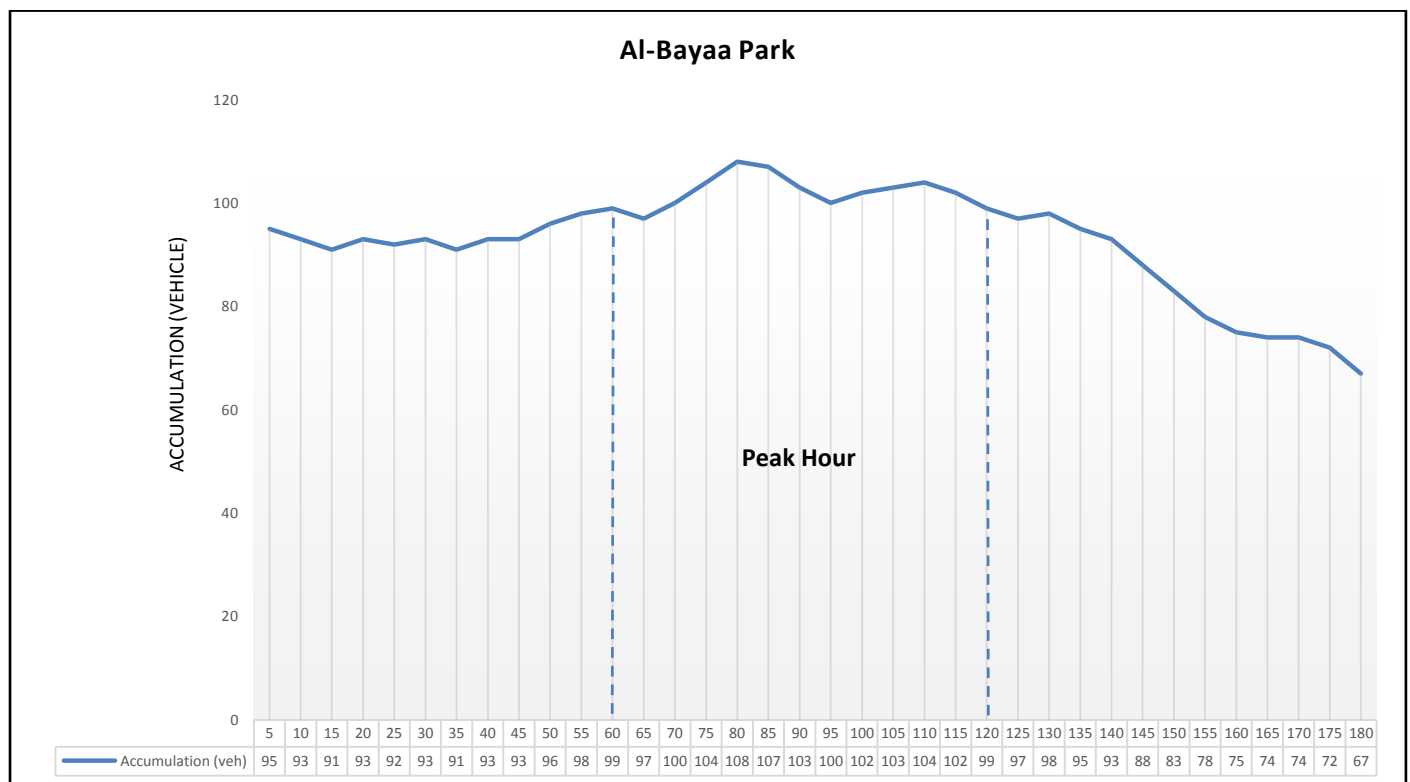


Figure 1.9 Accumulation Curve of Al-Bayaa Park

6.4 Allawi Southern Park (P4)

Data results from Table 1.9 and Figure 1.10, shown that the peak hour time for the study of this park is from (1:00-2:00) P.M. It also, gives average PI, PD and PT of 35.71 %, 38.88 min/veh and 0.55 veh/space respectively, where the PI below the maximum capacity (PI = 50%), therefore; the results classify the park is adequate in performance.

Table 1.9 Data Results of Alawi Southern Park

| Remarks | | Time (min) P.M. | Arrival | Departure | Accumulation (veh) | Parking Index, PI (%) | Parking load, PL (veh. min.) |
|----------------|-------|--------------------------|---------|-----------|-----------------------|--------------------------|---------------------------------|
| Initial count | 412 | 1:00-1:05 | 7 | 20 | 399 | 39.90 | 1995 |
| | | 1:05-1:10 | 10 | 19 | 390 | 39.00 | 1950 |
| Spaces | 1000 | 1:10-1:15 | 11 | 22 | 379 | 37.90 | 1895 |
| PV (veh) | 551 | 1:15-1:20 | 16 | 21 | 374 | 37.40 | 1870 |
| PL (veh. min.) | 21425 | 1:20-1:25 | 14 | 15 | 373 | 37.30 | 1865 |
| PD (min) | 38.88 | 1:25-1:30 | 12 | 20 | 365 | 36.50 | 1825 |
| PT (veh/space) | 0.55 | 1:30-1:35 | 9 | 23 | 351 | 35.10 | 1755 |
| PI (%) | 35.71 | 1:35-1:40 | 10 | 18 | 343 | 34.30 | 1715 |
| | | 1:40-1:45 | 8 | 25 | 326 | 32.60 | 1630 |
| | | 1:45-1:50 | 15 | 15 | 326 | 32.60 | 1630 |
| | | 1:50-1:55 | 12 | 10 | 328 | 32.80 | 1640 |
| | | 1:55-2:00 | 15 | 12 | 331 | 33.10 | 1655 |
| | | 2:00-2:05 | 10 | 20 | 321 | 32.10 | 1605 |
| | | 2:05-2:10 | 5 | 18 | 308 | 30.80 | 1540 |
| | | 2:10-2:15 | 10 | 20 | 298 | 29.80 | 1490 |
| | | 2:15-2:20 | 15 | 19 | 294 | 29.40 | 1470 |
| | | 2:20-2:25 | 10 | 25 | 279 | 27.90 | 1395 |
| | | 2:25-2:30 | 15 | 20 | 274 | 27.40 | 1370 |
| | | 2:30-2:35 | 15 | 15 | 274 | 27.40 | 1370 |
| | | 2:35-2:40 | 5 | 15 | 264 | 26.40 | 1320 |
| | | 2:40-2:45 | 15 | 10 | 269 | 26.90 | 1345 |
| | | 2:45-2:50 | 15 | 10 | 274 | 27.40 | 1370 |
| | | 2:50-2:55 | 15 | 15 | 274 | 27.40 | 1370 |
| | | 2:55-3:00 | 10 | 9 | 275 | 27.50 | 1375 |
| | | 3:00-3:05 | 10 | 12 | 273 | 27.30 | 1365 |
| | | 3:05-3:10 | 3 | 14 | 262 | 26.20 | 1310 |
| | | 3:10-3:15 | 7 | 10 | 259 | 25.90 | 1295 |
| | | 3:15-3:20 | 11 | 8 | 262 | 26.20 | 1310 |
| | | 3:20-3:25 | 10 | 6 | 266 | 26.60 | 1330 |
| | | 3:25-3:30 | 8 | 10 | 264 | 26.40 | 1320 |
| | | 3:30-3:35 | 5 | 5 | 264 | 26.40 | 1320 |
| | | 3:35-3:40 | 6 | 8 | 262 | 26.20 | 1310 |
| | | 3:40-3:45 | 3 | 10 | 255 | 25.50 | 1275 |
| | | 3:45-3:50 | 6 | 12 | 249 | 24.90 | 1245 |
| | | 3:50-3:55 | 5 | 7 | 247 | 24.70 | 1235 |
| | | 3:55-4:00 | 4 | 6 | 245 | 24.50 | 1225 |
| | | Total during Peak Hour | | | | 428.50 % | 21425 veh. min. |
| | | Average during Peak Hour | | | | 35.71 % | 357.08 veh. hr. |

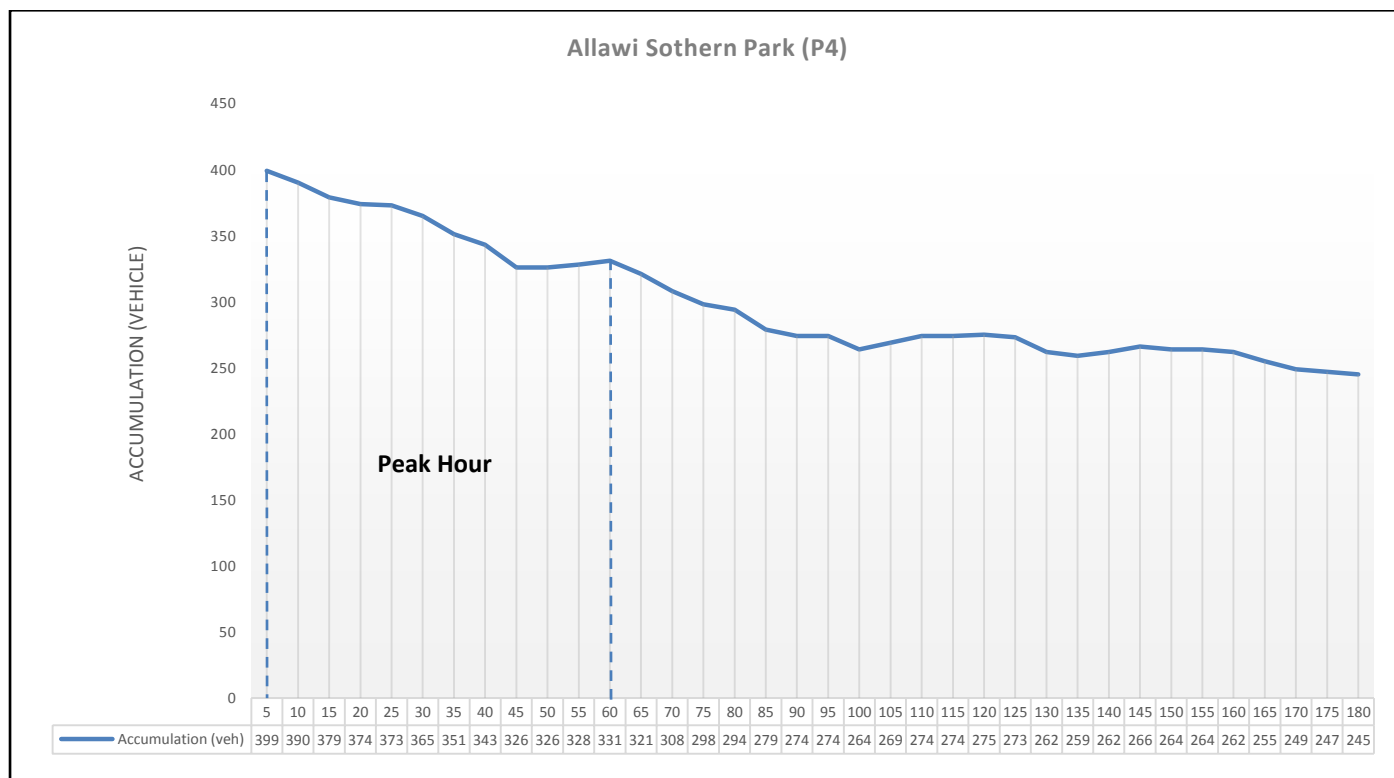


Figure 1.10 Accumulation Curve of Allawi Sothern Park

6. CONCLUTIONS

Three hours per day was taken in consideration to obtain peak hour performance based on previous data and questionnaires. It was noted that the peak time for P1 and P4 is from (1:00-2:00), P2 is from (6:50-7:50) A.M. and P3 is from (2:00-3:00) P.M. On the other hand, Arrival-Departure method is used for evaluating PI, PD and PT which express the case of parking efficiency. It showed that PI is 57, 97.72, 39.39 and 35.71%, also PD is 41.71, 43.11, 42.67 and 38.88 min, in addition that PT is 0.82, 1.36, 0.55, 0.55 veh/space for P1, P2, P3 and P4 respectively. The study showed that P1 and P2 operated below the maximum capacity at PI lower than 50%, it also gave indication that P2 sometimes operates with an over capacity, this may due to bad management of the park in addition to the non-properly use for the electronic system which controls on entrance gates. Furthermore. It showed that P3 and P4 operated above the maximum capacity complying with policy 7 of the parking space requirements in parking code guidance 2012 of San Francisco Department of Transportation.

7. RECOMMENDATIONS

It is necessary to design a computerized system (especially web-page including a server join the state company for private transport with all parks) controlling on the arrival and departure vehicles and storing data for at least a month. Also, encourage pedestrians not to use vehicles parked near to park that discordant to the legal parking. On the other hand, the possibility of converting the park management to investment management or public-private partnership.

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